LOWLYING ANCIENT TERRAIN (LAT) ON MARS: THE WESTERN ARABIAN SHELF (WAS)

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SUMMARY

The Western Arabian Shelf (WAS) region is the largest of several on Mars that depart from the normal paradigm of "cratered highlands". Although heavily cratered, the region lies 1-2 km below the average elevation, and therefore significantly lower than most of the cratered terrain on Mars. The downhill slope toward the Chryse impact basin has the character of a broad shelf, portions of which are covered by isolated outcrops of Hesperian ridged plains. The westernmost section is noticeably depleted in large craters and small basins. Crustal thickness models suggest this area is also much thinner than other cratered terrain, but still thicker than than the younger northern lowlands. We explore several possible reasons for this large area of lowlying ancient terrain. The Western Arabian Shelf (WAS) may be a good analog of the terrain which underlies the northern lowland plains.

INTRODUCTION

Most cratered terrain on Mars lies at or above the mean planetary elevation. Exceptions occur in Tempe Terra, along the dichotomy boundary east of the Isidis basin, and in western Arabia, where heavily cratered terrain lies below the planetary average and therefore 3-4 km below most martian cratered terrain. Figure 1a shows topographic contours in a zero-mean reference frame superimposed on a simplified terrain age map for the region where the largest example (~8 million km^2) of such Lowlying Ancient Terrain (LAT) occurs. Topography slopes downhill SE to NW over 4000 km from >2 km high in *Npld* terrain in Arabia to a -3 km low in the Chryse Basin. The cratered terrain (*Npl_1, Npl_2*) on the east side of the Chryse Basin lies mostly between -2 and -1 km and has the character of a broad shelf, abruptly rising by 2 km to the east where the terrain changes to *Npld*. About 40% of the lower area is covered by individual embayments of Hesperian-age ridged plains (*Hr*). The steeper rise to normal cratered elevations is similar to that along the dichotomy boundary in eastern Mars, suggesting the lower WAS may be a good (unflooded) analog of the surface under the lowland plains in Utopia.

Crustal thickness models suggest this region is also unusually thin for cratered terrain [1]. For a model based on the Mars50c gravity field [2] with a crust-mantle density contrast of 0.5 gm/cc and an average crustal thickness of 65 km, the WAS crustal thickness averages 45-55 km, thicker than the adjacent Chryse Basin (< 40 km) but significantly thinner than most cratered terrain (75-85 km).

Figure 1b shows large craters and small multiring basins in the study area. Those >200 km are noticeably missing from the lower western portion of the WAS. Multiring and larger impact features are found only at elevations > -1 km (except for the apparently exhumed Aram Chaos and Deuteronilus A&B Basins [3]), and tend to cluster where elevations steepen, particularly between -1 and +1 km.

Figure 1c shows how the region would appear if it had been resurfaced by Hesperian-age plains to a uniform elevation of -2 km. This is very similar to the actual situation (Figure 1a,b). Figure 1d shows how the WAS would change if such resurfacing were to -1 km. Substantial amounts of cratered terrain would be covered, and the area would appear similar to the crustal dichotomy boundary zone in eastern Mars in having a relatively abrupt topographic and physiographic transition.

Below we consider end member processes that could explain both the low and thin crust in this region as well as the distribution of large impact craters and small multiring basins, as shown in Figure 1.

MODELS FOR THE ORIGIN OF LOWLYING ANCIENT TERRAIN

Subcrustal erosion and subsidence could produce lowered ancient cratered terrrain, as previously suggested for the northern lowlands of Mars [4, 5]. However, by itself tectonic lowering can not explain the observed distribution of large impact craters and small basins, which should have formed throughout the region regardless of the elevation. Hesperian-age resurfacing (mostly *Hr*) in the WAS is limited and appears inadequate to have covered craters and basins larger than 200 km in diameter.

Large scale impact excavation can thin and lower the crust, and perhaps account for the missing large impact craters. A single crater the size of the Utopia Basin [6, 7], fits the existing topography extremely well, closely following the -1 km contour not only in western Arabia but also through Xanthe

and Tempe. The large craters outside this contour could represent a pre-existing population not removed by impact, but it is difficult to explain the Aram Chaos and Deuteronilus basins this way.. Also, a Utopia-size impact basin should leave Utopia-like crustal thicknesses (~20 km), whereas the crust within the WAS is twice this thickness (45-55 km). The smaller Chryse-Acidalia Basins [8] lie well within the -1 km circle, but perhaps ejecta from these could have buried large craters out to 1.5 basin diameters. Aram Chaos and the Deuteronilus basins might be exhumed members of an ejecta-buried pre-existing population, and the others a surviving population never buried by ejecta.

A combination of tectonic lowering followed by large impacts might explain the topography and distribution of large craters, but requires targeting of pre-existing, early-forming lowlands. Early tectonic lowering may have been enhanced by post-impact subsidence if that extended to a great distance from the impact. In any case, if large basin-forming impacts are invoked to explain the observed distribution of large craters, they must occur after the population of such craters has formed.

REFERENCES: [1] Frey, H.V. et al., LPSC XXVII, 381-382, 1996 and submitted to JGR Planets. [2] Konopliv, A.S. and W.L. Sjogren, JPL Pub. 95-5, 1995. [3] Schultz, P.H. et al., JGR 87, 9803-9820, 1982. [4] Wise, D.U. et al., JGR 84, 7934-7939, 1979. [5] McGill, G.E. and A. M. Dimitriou, JGR 95, 12,595-12,605, 1990. [6] McGill, G.E., JGR 94, 2753-2759, 1989. [7] Schultz, R.A. and H.V. Frey, JGR 95, 14,175-14,189, 1990. [8] Stockman, S.A. and H. Frey, GRL 22, 1269-1272, 1995.

FIGURE 1: Lowlying Ancient Terrain in the Western Arabian Shelf region of Mars. Background maps represent terrain ages: Black = Earliest Noachian, Dark Gray = Noachian, Light Gray = Hesperian, White = Amazonian. (a) Topography relative to zero mean elevation (thickest contour). Thick contours = positive elevations, thin contours = negative elevations. Contour interval = 1 km. Note broad region of Noachian terrain below zero contour. (b) Craters and small multiring basins larger than 100 km across. Zero topographic contour for reference. Note clustering of small basins along this contour. (c) Hypothetical Hesperian resurfacing to a uniform elevation of -2 km (light gray), similar to existing situation on Mars. (d) Same as (c) but hypothetical resurfacing to -1 km, which would eliminate most of the smaller craters within the light gray area, creating a situation similar to that along the dichotomy boundary in Utopia. See text.